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SUMMARY REPORT ON EFFLUENT DISPOSAL CON-
SIDERATIONS IN POSSIBLE PULP AND PAPER MILL
DEVELOPMENTS IN SOUTHEASTERN MISSOURI

Public Health Service
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SUMMARY REPORT ON
EFFLUENT DISPOSAL CONSIDERATIONS IN POSSIBLE
PULP AND PAPER MILL DEVELOPMENTS
IN SOUTHEASTERN MISSOURI

Prepared By The
U. S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
Public Health Service
Water Supply and Pollution Control Division

In Cooperation With The
Missouri Water Pollution Board
State of Missouri

Washington, D. C.

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SUMMARY REPORT ON
EFFLUENT DISPOSAL CONSIDERATIONS IN POSSIBLE
PULP AND PAPER MILL DEVELOPMENTS
IN SOUTHEASTERN MISSOURI

This report summarizes information obtained in a preliminary effluent disposal study of certain river basin areas which have been suggested as possible locations for pulp and paper mills in the southeastern portion of the State of Missouri. The river basins involved in the study were Gasconade, Current, Black, St. Francis, Big, and Meramec Rivers and the portion of the Mississippi River from Sainte Genevieve to New Madrid, Missouri. The reconnaissance survey of potential mill sites was made in keeping with the request and interest shown by the Missouri Water Pollution Board and other State and Federal agencies. Principal areas considered were:

- (1) Gasconade River near Rich Fountain
- (2) Gasconade River near Jerome
- (3) Current-Jacks Fork Rivers near Eminence
- (4) Current River near Van Buren
- (5) Current River near Doniphan
- (6) Black River near Poplar Bluff
- (7) St. Francis River near Fisk
- (8) Mississippi River -
 - (a) New Madrid, (b) Birds Point, (c) Cape Girardeau,
 - (d) Sainte Genevieve areas
- (9) Big River near Leadwood
- (10) Meramec - Steelville to St. Clair Section

The State of Missouri Conservation Commission and the Forest Service, U. S. Department of Agriculture, have conducted extensive studies in appraising timber resources that might be available for pulping in southeastern Missouri. The water and wastes disposal considerations, however, were the primary basis for this reconnaissance survey. The field work was conducted with representatives of the Missouri Water Pollution Board, Missouri Conservation Commission, Forest Service Rolla Office, U. S. Department of Agriculture, and Public Health Service, Region VI, U. S. Department of Health, Education, and Welfare. During and subsequent to the field work, considerable data and information have been furnished by a number of individuals and agencies, which have been very helpful in studies conducted in preparation of this report. The findings from the survey are briefly as follows:

Summary and Conclusions

1. Extensive timber resources exist in Missouri, particularly in the south and southeastern portion, or Ozark region, of the State. Forest land in the Eastern Ozarks, now predominantly covered by hardwoods, comprises about three-fourths of the land area. Increasing demands for pulp and paper products and technological developments in recent years have resulted in marked increase in pulping of hardwoods. This has brought forest resources in Missouri under active consideration for pulp and paper production. In considering possible sites for mills, water needs and extent of pollution of the streams by wastes from such mills is an important factor requiring careful attention.
2. Application of modern forest management in the eastern Ozarks, is not only tending to better timber production and quality, but has resulted in almost doubling the growth stock of softwoods over the past twelve years--a noteworthy trend as regards future supply of pulpwood. In the Mississippi River border area there are substantial amounts of cottonwood and other so-called soft hardwoods, which are relatively fast growing and a good source of pulpwood.
3. Consideration of pulpwood resources in relation to potential pulping processes at mills in Missouri, indicates hardwood sulphate, or kraft, pulping, along with neutral sulfite semi-chemical, cold soda, and other of the more recent processes for pulping hardwoods will be employed. Chemi-groundwood and groundwood pulping will be utilized at such mills. Although other type mills may be considered in the future, this survey or study is limited to generally evaluating the pollution effects of the processes mentioned.
4. The introduction of pulp mill wastes into a stream will have some effect on the character or quality of the water in it. Unless adequately controlled, their impact on a stream may include removal of dissolved oxygen, fiber bottom deposits, toxicities to fish and fish foods, color, tastes and odors, foaming, and stimulation of Sphaerotilus growths. The important consideration is whether such changes as may occur will adversely affect existing and future desirable uses of the stream below the pulp mill and the extent or degree of any detrimental effects on such water uses.

5. It is expected that the minimum size mill to be established would have a capacity of 50 tons of pulp per day. Economic and other factors might indicate need for more than doubling this output. Furthermore, since semi-chemical and groundwood pulps should not be allowed to dry before conversion into paper products, such pulping processes generally will be integrated with paper manufacture. In this study it is assumed mills constructed will employ modern methods for keeping waste loads at a minimum.
6. Suitable effluent diffusion facilities will be essential to assure effective mixing of mill used waters with stream flow. In addition, protection of streams against overloads can be provided by installation of suitable facilities to enable regulated discharge during periods of low streamflow.
7. Such analytical work as performed during the field work involved in this study indicated most waters were at or near saturation for dissolved oxygen at the prevailing temperatures; with stream conditions observed being generally favorable as regards existing water quality.
8. It was evident from the study that there is very limited basic water quality data for the streams in Missouri. There is need for a comprehensive program to supply this necessary water quality information.
9. Water quality objectives have been developed and adopted January 7, 1954, by the Engineering Section of the Missouri Basin Health Council, for use as a guide for the pollution control program along the Missouri River. Other such objectives are being utilized along the Mississippi River. These guides, copies appended, have been employed by the State of Missouri in the development of its part of comprehensive pollution control activities for these particular rivers, and have been used as fundamental information in preparing this report.
10. There are a number of other factors besides water resources to meet mill needs that will require careful analysis before proceeding with possible pulp and paper developments. Considerations such as possibilities of atmospheric odor problems developing need to be given attention, with proximity to residential areas and factors that influence the strength and direction of travel of plant odors being studied in relation to suitable control methods.

11. Data and information regarding allowable mill capacities in areas along streams included in this study have been prepared on the premises and limitations set forth in this report, and should be considered only in accordance with this information:
 - a. The Gasconade River near Rich Fountain, Missouri can support a 90-ton-per-day semi-chemical, or hardwood kraft, pulp mill, with chemical recovery system, and integrated paper production;
 - b. The Gasconade River near Jerome, Missouri, has adequate water resources to provide for an 80-ton-per-day semi-chemical, or hardwood kraft mill, with chemical recovery, and conversion of pulp to paper products.
 - c. The water resources of the Current River in (1) the sector from below the mouth of Jacks Fork near Eminence, to Van Buren, Missouri, could take care of the needs of a 120-ton-per-day semi-chemical, or integrated hardwood kraft pulp mill, with chemical recovery system, and paper production; or (2) the sector from below Van Buren and Big Spring to the vicinity of Doniphan, Missouri, could take care of requirements for a 240-ton-per-day pulp and paper mill employing the above hardwood pulping processes. Existing and proposed park and recreational developments in the scenic Current River Valley augur strongly against mill developments in this area.
 - d. Near Poplar Bluff, Missouri, on the Black River, it would be practical to build a 65-ton-per-day semi-chemical, or integrated hardwood kraft, pulp and paper mill.
 - e. The St. Francis River in the vicinity of Fisk, Missouri, would have inadequate assimilative capacity to accommodate a pulp and paper mill of minimum capacity for economic operation.
 - f. The Mississippi River in areas near (1) New Madrid, (2) Birds Point, (3) Cape Girardeau, and (4) Sainte Genevieve, would be able to take care of effluents from each of the processes that might be employed for pulping hardwoods found in the river border area and Eastern Ozarks, with any mill having such daily capacity as might be considered economic for installation in these areas.

- g. The Big River in the Leadwood-DeSoto, Missouri, sector does not have the assimilative capacity needed to absorb the effluent from a pulp and paper mill of minimum economic size.
- h. The Meramec River in the sector from Steelville to St. Clair is not satisfactory for receiving the effluent from a minimum economic size pulp and paper mill. Despite exceptional measures taken to minimize and treat any mill effluent, extensive recreational use of this river would make it undesirable to locate a mill along this section. Downstream from the indicated sector the river is used as the source for Kirkwood and St. Louis County water supplies.

The foregoing findings are the results of field observations and study which included (1) assembly and analysis of hydrologic and climatologic information, estimated waste discharge, and available water quality data; and (2) correlation of collected information in terms of appropriate water quality objectives, as appended. The study necessitated the evaluation of future dissolved oxygen conditions in the waters of sections of streams indicated in southeastern Missouri, forecast under low flow, warm weather conditions with indicated types of pulp and paper production with mills of 50 tons, or greater, daily capacity located along the portions of streams covered by the survey; and consideration of the anticipated effects of the effluents on other stream characteristics related to present and anticipated future uses.

In any multipurpose development of water resources the aim is to make the waters increasingly useful in meeting needs, with a basic requirement generally being effective water quality management in the public interest. Quality needs of stream waters usually vary from basin to basin with the criteria applied in management practices usually being determined by the more exacting uses of the waters. Definite cognizance is taken in this study of views expressed by representatives of the State authorities participating in the survey that water quality objectives being used for the Missouri and Mississippi Rivers be considered as minimal when applied to tributaries or inland streams, such as the Gasconade, Meramec, Current and other Ozark rivers.

The importance of maintaining a high degree of cleanliness in the relatively unpolluted portions of these streams, and of providing for suitable utilization, treatment and disposal of existing and future

pollutional waste is recognized. Missouri has a valuable asset in its clear, cool, spring fed streams of the Eastern Ozark region, and in the border waters of the Mississippi River. The Ozark waters are already utilized to considerable extent for the benefit and enjoyment of both the citizens and visitors to the State. Accordingly, the essential problem is to conserve to the fullest extent possible the value of these waters for all purposes.

Pulping Processes

In the production of wood pulp, mechanical, chemical, semi-chemical, and chemi-groundwood processes have been employed. The acid sulfite process has been used extensively in the past with softwoods, but with the increased pulping in recent years of hardwoods, the neutral sulfite semi-chemical process has been increasingly employed in addition to alkaline pulping processes, to be briefly reviewed under the following headings:

Kraft Pulping Processes

The alkaline pulping processes, such as the sulfate process used for the manufacture of strong kraft wrapping papers and boards and the soda process used for the production of book and magazine papers, do not cause the serious pollution problems that acid processes do. Most of the spent liquors from the alkaline pulping processes are concentrated and burned, and the alkali recovered is reused in the process. A certain amount of the wash water goes into the streams. This effluent consists of the tailings and very dilute spent liquors containing so little chemical that recovery is unprofitable. Ordinarily this waste water causes no serious trouble if the recovery operation is functioning properly. However, the large volume of effluent from a big mill may cause pollution, particularly if the receiving stream does not have enough volume of flow to dilute and aerate the waste. Some large sulfate pulp mills pond the effluent in an oxidation lagoon from which the waste is discharged in regulated amounts. Other mills use oxidation treatments similar to the activated sludge sewage disposal systems, and some combine lagooning with treatment.

Other compounds, called mercaptans, are produced in sulfate pulping operations and occasionally get into the waste waters. Mercaptans are sulphur ethers or alcohols that are formed in the

cooking process. They have a very disagreeable odor and are toxic to fish life if present in the water in any appreciable amount. Concentrations greater than about one part per million are serious. Beyond this concentration, the nervous system of the fish is seriously impaired, and death eventually results. The quantity of mercaptans formed is small, and only when uncontrolled does their effect seem to be serious.

Semi-Chemical Pulping Processes

Semi-chemical pulping processes employ either solutions of sodium sulfite and sodium bicarbonate (neutral sulfite semi-chemical), sodium hydroxide and sodium sulfite (kraft semi-chemical), or sodium hydroxide only (cold soda semi-chemical). Kraft semi-chemical and cold soda spent liquors can be combined with kraft chemical pulping spent liquors and recovered in the usual systems. Neutral sulfite spent liquor can also be combined with kraft chemical pulping spent liquor up to about one-fourth of the recovery plant capacity. Semi-chemical plants not integrated with chemical pulping plants now have choice of several chemical recovery methods. At least seven such methods have been developed in recent years. Those that have been studied are the Zimmerman, Mead, Institute, Gauvin, Bradley, Sivola, and Stora-Kopparberg processes. (2)

Mills that are using some of these processes on spent liquor from pulping operations of 50 tons or more daily production have reported successful results. (3-4) In addition to chemical recovery for reuse in the semi-chemical processes of pulping of the hardwoods, there is considerable reduction of the waste loads on receiving streams, requiring lesser amounts of dissolved oxygen in the receiving waters to oxidize or stabilize such substances as remain in the effluent. It appears that the waste load as indicated by the biochemical oxygen demand of the spent liquor can be reduced from 50 to 90 percent by the above recovery processes.

It should be explained here that the waste loadings, or degree of pollution, is usually measured by the 5-day biochemical oxygen demand (B.O.D.). This determination measures the amount of oxygen that will be consumed by the waste waters or mill effluent. Values are now usually reported in terms of pounds of oxygen required per ton of product, which will be referred to later when discussing waste treatment.

Groundwood Pulping Process

This process involves pulping wood mechanically with suitable grinders. Hardwoods do not serve very well for groundwood pulping, paper making trends being toward substituting high yield semi-chemical pulps for groundwood pulp.

Paper Products Manufacture

Conversion of bleached or unbleached pulps into paper, paper-board, and other products usually involves relatively low waste loads as compared to acid or alkaline pulping processes. This is discussed under the following headings:

Paper Production Effluents

In the paper-making process, the sheet is formed by filtering the fibers from a water suspension on a fine-mesh wire screen of the Fourdrinier, or, paper machine. In the formation of the paper sheet, the water passing through the screen (white water) carries a considerable quantity of fiber. In order to avoid large losses of fiber, this white water is recirculated through the system. In other words, instead of adding fresh water for washing and dilution of pulp stock, the white water is used for this purpose. However, it usually results that there is a surplus of white water over that needed for make-up and the unused portion, after passing through filters or settling tanks, is discharged into the mill effluent. In addition to the cellulose fibers, white water effluent from paper mills may contain some clay or other mineral fillers, alum, rosin-size, and dye used in the manufacture of various kinds of paper. The quantities of suspended solids in the effluent from both pulp and paper mills may vary considerably among individual mills. This is a result of the different products being manufactured, the process used, type of equipment available, and method of operation.

The so-called 'white water' wastes, applied to the fiber and other paper-making materials in suspension, are kept at a minimum by recirculation. Save-all equipment is employed to remove the paper-making solids in the white water before discharge from mills. There is usually some type of filtering or clarifying device designed to return the reclaimed material to the pulp and paper making process. Utilizing more recent equipment, the losses of fiber may be reduced below a half pound per thousand gallons of effluent.

Paperboard Mills

In general the principles employed in reduction of white water wastes in paper mills are being followed in decreasing fiber losses in the manufacture of paperboard. The trend is toward recirculation of as much of the white water as possible without causing processing difficulties. This closing or partial closing of board mill white-water systems has increased the problem of slime control. As in paper mills, the situation has been met by use of antislime materials in the water, such as chlorine, chloramine, pentachlorophenate, and other compounds for suppressing biological growths. It is important to maintain careful control of such antislime compounds, or special processing wastes, that may contain enough free phenol to impart tastes to downstream water supplies.

Filtration, settling, and precipitation systems have been utilized to remove suspended solids from board mill wastes. For such solids as cannot be effectively and economically returned for use in the mill, disposal in lagoons may be the answer from the point of view of stream improvement.

Waste Treatment

Process and equipment improvements have resulted in a definite trend downwards in the volume and strength of pulp and paper mill effluents. The strength of the wastes on an oxygen demand basis has been decreased as much as 75 per cent by such improvements, with attendant reductions in chemical requirements, and other gains. Monitoring equipment is proving of value in avoiding occasional increases in sewer losses. The work on waste reduction is nearing an irreducible minimum, however, and further reductions necessitate consideration of treatment and disposal methods.

The Forest Service, U. S. Department of Agriculture, reported⁽⁵⁾ approximate B.O.D. values for various pulping processes, expressed in terms of pounds of oxygen per ton of pulp produced, as shown in the following tabulation:

<u>Process</u>	<u>B.O.D.</u>
Groundwood pulping	3- 8
Sulfate pulping	55-70
Cold-soda pulping*	50-100
Deinking plant wastes*	**60-100
Semi-chemical neutral sulfite pulping*	125-350
Sulfite pulping*	500-600

Even though some pulp mill effluents today are considerably weaker in pollutional characteristics than they were a few years ago, effluent disposal may involve more than dilution to avoid impairing the quality of the receiving waters. Such measures for treatment and disposal as have been employed in recent years with kraft mill wastes, have been directed toward reduction of waste components toxic to fish life as well as reduction in oxygen demand.⁽⁵⁾ In-plant improvements have removed a large portion of toxic sulphides and mercaptans from the composite mixture of flow stream condensate, evaporator condensate, and digester relief condensate following separation of the turpentine which is usually marketed or burned.

Usually when the effluents are controlled to maintain adequate dissolved oxygen in the receiving stream, problems of toxicity to fish will be satisfactorily overcome. Also with adequate stream dilutions at pulp mill sites there should be no appreciable effect on the quality of the waters for irrigation purposes.⁽⁶⁻⁷⁾

Treatment procedures are usually necessitated by insufficient dilution being available in the receiving waters. The need and type of treatment is related to stream use. It may be seasonal or continuous. Ponding or lagooning of wastes may be employed, or other more recently developed methods for the solution of special problems, can be applied.

* Without recovery or treatment.

**Per ton of waste paper processed.

Lagooning has been utilized with beneficial results in reducing the strength of kraft mill wastes, and in equalizing the flow and variations to be expected in strength of mill wastes. The use of lagoons of suitable capacity for effluents, therefore, gives flexibility in handling of wastes to avoid objectionable conditions during periods of low stream flow and highest water temperatures. (8-9) Special studies in recent years to increase the efficiency of lagoons have been conducted by the industry through their National Council for Stream Improvement, and much information is available on performance of this method for treatment and disposal of kraft mill effluents.

Biological methods of treatment practiced by some kraft pulp and paper mills include oxidation ponds, other natural purification procedures, and the accelerated aeration process. A natural purification method of increasing popularity in the United States consists of passing the mill effluent down a natural or man-made waterway, or series of lagoons, before discharge into the receiving stream. The accelerated aeration method for mill wastes which consists of effluent oxidation in an aeration tank by means of biological sludge or floc was experimentally developed by the National Council for Stream Improvement. A mill at Covington, Virginia, treats all of its wastes from wood preparation through bleaching operations by the accelerated aeration process and accomplishes high reduction of the oxygen demand of the mill effluent. (10-11)

Treatment efficiencies attainable are being further demonstrated at a new installation employing this modified activated sludge process and designed to receive, in addition to the pulp and paper mill wastes, the sewage from three municipalities. (12)

Progress is being made in the removal of color from kraft mill wastes. (13) Color may be removed by treatment of the effluents with high dosages of hydrated lime. This treatment produces large volumes of hydrous sludges which are difficult to de-water. In view of the amount of lime required for good results, it is necessary for economic reasons to recover the calcium content of the sludges for re-use. Promising methods for treatment of the sludge, employing carbonation and heat, are being mill-tested. (14)

Small daily losses of fiber from a pulp and paper mill may result in an extensive accumulation of fiber with time on the bottom of a receiving stream. It is especially true with a slow moving river or a fairly quiescent area such as a reservoir. Such a mat of fiber

tends to smother the aquatic organisms on which fish feed and will undergo slow decomposition which contributes to the benthal or stream bottom oxygen demand. Modern "save-all" equipment, such as vacuum filters, and water recycling systems, properly installed and operated should adequately take care of the fiber problem.

Conclusion

In conclusion, observations and studies indicate that certain previously designated sectors of rivers included in this reconnaissance survey of possible pulp and paper mill sites would appear to have the capacity to satisfactorily assimilate the effluents from semi-chemical, or hardwood kraft, pulping processes, with chemical recovery, and integrated production of paper and paperboard products. This report needs to be considered as a preliminary appraisal of the suitability of the sites from the point of view of impact on water quality only. When a definite proposal is made for the construction of a pulp and paper mill at any specific location, there should be a detailed evaluation of conditions to be met in carrying out the project. Suitable operation and treatment provisions can then be determined for each proposal to enable attainment of a high degree of stream cleanliness consistent with water uses.

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WATER QUALITY OBJECTIVES

The Engineering Section of the Missouri Basin Health Council, consisting of the chief sanitary engineers of the 10 Missouri Basin States, on January 7, 1954, adopted objectives as a guide for coordinated interstate water pollution control programs along the Missouri River. The guide has been employed by the State of Missouri in the development of its part of the comprehensive pollution control program, and was used as background information in carrying out this study. It is recognized that changes in conditions, particularly as they may affect water uses, and alterations in types of water uses, may require further modifications in any established objectives. The objectives adopted by the States of the Missouri Basin and used as a reference in this study are quoted as follows:

Missouri River:

"Subject to (a) such higher objectives as may be desired by any State and (b) such other modification as may be deemed necessary, after appropriate investigation, by the State Water Pollution Control Agency concerned, the Engineering Section, Missouri Basin Health Council, recommends the following for consideration by the member states as a guide for water pollution control activities in the Missouri Drainage Basin.

"1. Toxic substances including metallic ions, phenolic compounds, oils, alkalies, and acids should be virtually eliminated from sewage effluents.

"2. Removal of settleable and floating solids to prevent sludge banks, floating materials, and nuisance conditions should be required as the minimum acceptable treatment.

"3. For industrial wastes similar in nature to municipal wastes, treatment should be based on the same premise as recommended for municipalities. For industrial wastes not comparable to municipal wastes, treatment should be provided as necessary to prevent deterioration of water quality for beneficial uses in the receiving stream.

"4. Additional treatment over that specified in item 2 above should be provided as necessary to protect downstream water uses.

Quality objectives for certain water uses are:

"(a) For water serving as a source of domestic supply, raw water bacteriological quality should conform to that recommended in 'Manual of Recommended Water Sanitation Practices, 1946, Public Health Bulletin #296,' pages 11-13.

"(b) For bathing or swimming waters, monthly arithmetical average 'most probable number' of coliform organisms should not exceed 1,000 per 100 ml. during any month of the recreational season; nor exceed this number in more than 20 percent of the samples examined during any month; nor exceed 2,400 per 100 ml. on any day. For nonbathing or nonswimming waters, the monthly arithmetical average 'most probable number' of coliform organisms should not exceed 5,000 per 100 ml. in any month of the recreational season, nor should exceed this number in more than 20 percent of the samples examined during any such month.

"(c) For fish and aquatic life a minimum oxygen concentration of 5.0 ppm is desirable in waters otherwise offering suitable fishery habitat, with 6.0 ppm for trout streams.

"(d) For bacteriological quality of irrigation water:

"(1) Sewage used for irrigation of forage crops should be given treatment insuring a consistent reduction in coliform bacteria of not less than 90 percent.

"(2) Sewage used for irrigation of human food crops should be given treatment insuring a consistent reduction (a) in suspended solids of not less than 75 percent, (b) in 5 day 20°C B.O.D. of not less than 75 percent and (c) in coliform bacteria of not less than 98 percent, unless discharged into a stream where the volume of dilution water, available during the low flow periods during which irrigation diversions may occur, is at least 10 times greater than anticipated maximum daily volume of sewage, in which case a bacterial reduction of 90 percent may be acceptable.

"Provided, however, that where the time of passage from plant discharge to irrigation diversion is such as to permit the normal death rate of bacteria as evidenced by the die-away curve to provide equivalent bacterial reduction, the requirements of (1) and (2) above may be appropriately modified."

Mississippi River:

As a result of a pollution study of the Mississippi River in and downstream from the St. Louis Metropolitan area sponsored by the Bi-State Development Agency and conducted cooperatively with the States of Missouri and Illinois, and the U. S. Public Health Service during the period 1951-52*, the following water quality objectives were developed for the interstate waters and used in connection with further activities reported in 1958**, and as a basic reference in so far as this study is concerned with the Mississippi River:

General Objectives

"All wastes, including sanitary sewage, storm water, and industrial effluents, shall be in such condition when discharged to the Mississippi River that they will not create conditions in that stream which will adversely affect the use of those waters for the following purposes: source of domestic water supply or industrial water supply, navigation, fish, and wildlife, recreation, agriculture and other riparian activities."

"In general, adverse conditions are caused by:

- A. Excessive bacterial, physical or chemical contamination.
- B. Unnatural deposits in the stream, interfering with fish and wildlife, recreation, or destruction of aesthetic values.
- C. Materials imparting objectionable colors, tastes or **odors** to waters used for domestic or industrial purposes.
- D. Floating materials, including oils, grease, garbage, sewage solids, or other refuse."

* "Mississippi River Pollution Investigation, St. Louis Metropolitan Area", Bi-State Development Agency, 1954.
** "Pollution of Interstate Waters of the Mississippi River in the St. Louis Metropolitan Area", Bi-State Development Agency, February, 1958.

Specific Objectives

"In more specific terms, adequate controls of pollution will necessitate the following objectives for:

A. Sanitary Sewage and Storm Water

"Sufficient treatment for adequate removal or reduction of solids, bacteria and chemical constituents which may interfere unreasonably with the use of these waters for the purposes aforementioned. Adequate protection for these waters would be provided by:

- (a) Substantially complete removal of floating and settleable solids; and
- (b) Removal of not less than forty-five per cent of the total suspended solids."

B. Industrial Wastes

(1) Chemical Wastes - Phenolic Type

"Industrial waste effluents from phenolic hydrocarbon and other chemical plants will cause objectionable tastes or odors in drinking or industrial water supplies and may taint the flesh of fish. Adequate protection should be provided for these waters if the concentration of phenol or phenol equivalents does not exceed a monthly average of 2 parts per billion and a maximum of 5 parts per billion at any point in these waters following initial dilution."

(2) Chemical Wastes - Other Than Phenolic

Adequate protection should be provided if:

- (a) The pH of these waters following initial is not less than 6.7 or more than 8.5.
- (b) The odor-producing substances in the effluent are reduced to a point that following initial dilution with these waters the mixture does not have a

monthly average threshold odor number in excess of 10 and a maximum daily odor number in excess of 30.

- (c) Oils and floating solids are reduced to a point such that they will not create fire hazards, coat hulls of water craft, injure fish or wildlife or their habitat, or will adversely affect public or private recreational development or other legitimate shoreline developments or uses. In order to accomplish this it will be necessary to reduce contrations of such materials discharged to the point where after initial dilution the stream shall be free of noticeable floating solids, oil, grease, and sleek."

(3) Highly Toxic Wastes

"Adequate protection should be provided for these waters if substances highly toxic to human, fish, aquatic or wildlife are eliminated or reduced to safe limits."

(4) Deoxygenating Wastes

Adequate protection of these waters should result if sufficient waste reduction process changes or if sufficient treatment is provided to accomplish substantially the same objectives as are herein set up for sanitary sewage...."

Guiding Views on Objectives

Communications on objectives in relation to this study have emphasized that the policy of the Missouri Water Pollution Board is to establish objectives for each stream based upon water quality requirements to meet various needs determined by water uses. While objectives have not been established for the tributary streams to the Missouri and Mississippi Rivers, the indication is that the above provisions, or more stringent requirements, could be expected to prevent detrimental effects in any multipurpose development of the inland waters covered by this reconnaissance survey.

It has been pointed out that the view of the Missouri Conservation Commission in administering forest, fish and game resources is that such water quality objectives as established for these streams adequately safeguard sport fishery, game, and other natural assets. To maintain such objectives the Commission advocated that the best known waste treatment practices for the waste waters from industry be provided, and even this might not be satisfactory insurance against damage to sport fishery. Operation and maintenance is important. It is further indicated that this is particularly true in the inland streams of Missouri where a high quality sport fishery of national reputation is concerned. Their feeling is that the provisions reviewed in this report would be minimal in the protection of the sport fishery and the game resource, and that such resources can be protected only through intensive planning for the most effective known treatment of wastes resulting from the pulp and paper industry.